

WHAT IS CLAIMED IS:

1. A method of conducting hydrate-based desalination or water purification in a hydrate fractionation column, said method comprising:

introducing hydrate-forming substance into a lower, hydrate formation region of said hydrate fractionation column where saline or otherwise polluted water to be treated is present, said water to be treated being under temperature and pressure conditions sufficient for hydrate to form upon introduction of said hydrate-forming substance into said hydrate formation region, whereby positively buoyant or gas-assisted positively buoyant hydrate forms within said hydrate formation region,

allowing said hydrate to rise within said hydrate fractionation column toward a hydrate dissociation region of said hydrate fractionation column,

allowing said hydrate to dissociate to release fresh or purified water and said hydrate-forming substance, said fresh or purified water collecting in said upper, hydrate dissociation region of said hydrate fractionation column, and

collecting fresh or purified water product water,

said method further comprising removing a portion of said fresh or purified water from an upper region of said hydrate fractionation column and reintroducing said removed portion of fresh or purified water into said hydrate fractionation column at a lower, reintroduction region thereof, said reintroduction region being located above said hydrate formation region of said hydrate fractionation column.

2. The method of claim 1, wherein a fresh or purified water region of said hydrate fractionation column extends downwardly from said hydrate

dissociation region and a mixture of fresh or purified water, hydrate, and gaseous hydrate-forming substance is present within said fresh or purified water region of said hydrate fractionation column, and

wherein said removed portion of fresh or purified water is reintroduced into said hydrate fractionation column at a lower region of said fresh or purified water region of said hydrate fractionation column.

3. The method of claim 2, wherein a circuitous fluid flow pathway extends from said reintroduction region of said hydrate fractionation column, up along said fresh or purified water region of said hydrate fractionation column, and down along a fresh or purified water down-flow conduit through which said removed portion of fresh or purified water flows to said reintroduction region, and

wherein the density of said mixture of fresh or purified water, hydrate, and gaseous hydrate-forming substance that is present in said fresh or purified water region of said hydrate fractionation column is less than the density of said removed portion of fresh or purified water, whereby a circulatory system of fluid automatically rising within said fresh or purified water region of said hydrate fractionation column and flowing down along said fresh or purified water down-flow conduit is maintained.

4. The method of claim 3, further comprising controlling the rate of flow of said circulatory system so as to maintain a desired upward flow rate of hydrate within said fresh or purified water region of said fractionation column.

5. The method of claim 3, further comprising initiating the flow of fresh or purified water down along said fresh or purified water down-flow conduit using a pump.

6. The method of claim 5, further comprising generating electrical power as fluid automatically flows through said pump, as part of said circulatory system, due to the difference between the density of said mixture of fresh or purified water, hydrate, and gaseous hydrate-forming substance that is present in said fresh or purified water region of said hydrate fractionation column and the density of said removed portion of fresh or purified water that is in said fresh or purified water down-flow conduit.
7. The method of claim 1, wherein said portion of fresh or purified water is removed from said hydrate dissociation region.
8. The method of claim 1, wherein said portion of fresh or purified water is removed from said hydrate dissociation region via a degassification manifold that extends downwardly from said hydrate dissociation region.
9. The method of claim 8, wherein said portion of fresh or purified water is degassified in said degassification manifold.
10. The method of claim 8, wherein said fresh or purified product water is collected by being withdrawn from said degassification manifold.
11. The method of claim 1, further comprising recovering gaseous hydrate-forming substance, released upon dissociation from said hydrate, from said hydrate dissociation region of said hydrate fractionation column.
12. The method of claim 11, further comprising re-using said recovered hydrate-forming substance for further cycles of hydrate-based desalination or purification.
13. The method of any one of claims 1-12, wherein said hydrate fractionation column comprises a shaft formed in land, said hydrate formation

region being formed at a lower portion of said in-land shaft, said method further comprising providing input water to be treated into said hydrate fractionation column at a location that is generally at or above the highest point within said hydrate formation region at which hydrate is formed.

14. The method of claim 13, wherein heated residual brine or other heated residue of said water to be treated is removed from a lower portion of said hydrate formation region of said hydrate fractionation column, thus removing heat of exothermic hydrate formation from said hydrate formation region.

15. The method of any one of claims 2-12, wherein the rate at which said removed portion of fresh or purified water is reintroduced into said hydrate fractionation column is controlled so as to maintain general separation between, and minimize mixing of, fresh or purified water in said fresh or purified water region of said hydrate fractionation column and seawater, residual brine, or other residual fluid below said fresh or purified water region of said hydrate fractionation column.

16. The method of claim 15, further comprising removing mixed salinity or mixed purity fluid that does result from mixing of said fresh or purified water in said fresh or purified water region of said hydrate fractionation column with said seawater, residual brine, or other residual fluid.

17. The method of any one of claims 2-12, wherein the manner in which said removed portion of fresh or purified water is reintroduced into said hydrate fractionation column is controlled so as to maintain general separation between, and minimize mixing of, fresh or purified water in said fresh or purified water region of said hydrate fractionation column and seawater,

residual brine, or other residual fluid below said fresh or purified water region of said hydrate fractionation column.

18. The method of claim 17, further comprising removing mixed salinity or mixed purity fluid resulting from mixing of said fresh or purified water in said fresh or purified water region of said hydrate fractionation column and said seawater, residual brine, or other residual fluid.

19. The method of any one of claims 1-12 and 14, further comprising pre-treating said water to be treated with hydrate-forming substance without causing hydrate to form.

20. The method of claim 13, further comprising pre-treating said water to be treated with hydrate-forming substance without causing hydrate to form.

21. The method of claim 15, further comprising pre-treating said water to be treated with hydrate-forming substance without causing hydrate to form.

22. The method of claim 16, further comprising pre-treating said water to be treated with hydrate-forming substance without causing hydrate to form.

23. The method of claim 17, further comprising pre-treating said water to be treated with hydrate-forming substance without causing hydrate to form.

24. The method of claim 18, further comprising pre-treating said water to be treated with hydrate-forming substance without causing hydrate to form.